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AIR PERMEABILITY OF FABRICS

E.V. Kondratski

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Air flows through cloth by way of the interfilamentary and intrafilimentary pores; but, if the cloths are made of threads of sufficient twist or out of monofils, the distribution of the air will be conditioned by the passage of air through the interfilamentary pores (the meshes).

According to the existing testing method the air-permeability of cloth is determined by a fall of pressure of 5 mm of water stream and with falls in pressure for monofil cloths the states of flow will be turbulent. ~~We~~ The ~~will~~ consider the process of the airflow through the meshes to be adiabatic and constant. We will also suppose that the air leaves the mesh in a free turbulent stream and that all the measurements characterizing the process are conditioned by the mesh cross-section. Then from the equation for the adiabatics and the equation for the conservation of energy it follows that the full volume of air V, flowing through a specimen of a unit of area for a unit of time when the given fall in pressure is Δp will be

$$V = \mu f \sqrt{2 \frac{\gamma}{\gamma - 1} \frac{p_o}{\rho_o} \left[1 - \left(\frac{p_1}{p_o} \right)^{\frac{\gamma - 1}{\gamma}} \right]}$$

when

f	-	summary area of all the meshes in one unit of area of the given specimen;
$\gamma = \frac{C_p}{C_v}$	-	adiabatic index;
p_o, ρ_o	-	correspondingly absolute pressure and density of the air before the cloth;
p_1	-	absolute air pressure behind the cloth;
μ	-	air coefficient, calculating the losses in mechanical energy when the air passes and, with friction, passes through the mesh and also when the stream is compressed [2].

When there are small drops in pressure and the effect of the change in the air density is small ($\gamma = 1.4$; $0.53 < \frac{p_1}{p_o} < 1$) one can assume an approximation:

$$\frac{\gamma}{\gamma - 1}\left[1 - \left(\frac{p_1}{p_o}\right)^{\frac{\gamma-1}{\gamma}}\right] \doteq 1 - \frac{p_1}{p_o}.$$

In this case the calculation can be worked out by the approximate formula

$$V = \mu f \sqrt{\frac{2}{\rho_o}\Delta p}. \tag{2}$$

when $\Delta p = p_o - p_1$ - the fall in pressure on the material/cloth.

The theory of similarity and regularity allows a system of physical parameters to be determined on which the coefficient of the distribution μ depends, and it can be expressed by

$$\mu = \mu\left(\frac{l}{h};\ \frac{b}{h};\ Re;\ M\right), \tag{3}$$

when $\frac{l}{h}, \frac{b}{h}$ - the criteria determining the geometrical similarity of the meshes;

b and h - correspondingly the breadth and height of the mesh ($b > h$);

l - thickness of the cloth;

$Re\ \frac{\rho_o u d_2}{\eta_o}$ - Reynolds criterion characterizing the order of the relation of the forces of inertia to the forces of viscosity;

$d_{\Gamma} = \frac{2bh}{b + h}$ - hydraulic diameter;

η_o - coefficient of the dynamic viscosity of air;

u - mean speed of the flow, determined by the longitudinal gradient of pressure;

$M = \frac{u}{\sqrt{\gamma RT}}$ - Max. criterion determining the phenomena linked with the air's compressibility;

$\overline{R} = gR$ - gas constant;

g - acceleration of free fall;

R - gas constant (for air R = 29.27 m/deg);

T - absolute temperature in the flow.

At an airflow speed of less than 100 metres per second the air can practically be considered non-compressible[3,4] and the dimension μ can be determined by the formula

$$\mu = \mu\left(\frac{l}{h}, \frac{b}{h}, Re\right). \tag{4}$$

It should be noted that with cloths prepared from yarn the form of the meshes are far from right-angles and the geometrical similarity of such meshes must be determined by the one criterion $\frac{l}{d_2}$,

when $d_2 = \frac{4f_1}{\Pi}$ - hydraulic diameter;

f_1 - the area of the cross-section of the mesh;

Π - the perimeter of the cross-section of the mesh.

Fleeciness has a great influence on the character of the passage of air through the meshes of the named cloths, therefore to the above-mentioned criteria (3) we must add the criterion for fleeciness.

The formula (2) was checked on gauzes whose structural chracteristics have been entered in Table 1. The diameters of the threads and the dimensions of the meshes were determined by microscope type TEM, the vclumetrical air distribution V through the cloths on instrument type UPV-2 for determining the air-permeability of cloths. The coefficient of the distribution was determined as being $\mu = \frac{V}{V_\tau}$,

when

$$V_\tau = f\sqrt{\frac{2}{\rho_0}\Delta p} - \tag{5}$$

is the volumetric distribution of air through a cloth, supposing that $\mu = 1$, that is supposing that stream compression and resistance are absent.

Table 1

No. Art.	Thickness in texes (number) of thread	Density of cloth 10 cm $П_o = П_y$	Diameter of thread in mkm	Number of meshes per 1 cm^2	Dimensions of mesh in mkm	Surface porosity (coefficient of living section)
8	50(20)	80	240	64	1010	0.650
9	50(20)	90	240	81	875	0.620
10	50(20)	100	240	100	760	0.575
11	50(20)	110	240	121	700	0.595
12	50(20)	120	240	144	600	0.520
13	20(50)	130	155	169	620	0.654
14	20(50)	140	155	196	560	0.620
15	20(50)	150	155	225	520	0.610
16	20(50)	160	155	256	490	0.615
17	20(50)	170	155	289	440	0.560
18	20(50)	180	155	324	410	0.545
19	10(100)	190	110	361	420	0.640
20	10(100)	200	110	400	394	0.622
21	10(100)	210	110	444	370	0.610
23	10(100)	230	110	529	330	0.580
25	10(100)	250	110	625	300	0.565
27	10(100)	270	110	729	265	0.513
29	6.67(150)	290	87	841	253	0.540
35	5(200)	350	78	1225	214	0.560
38	4(250)	380	68	1444	195	0.550
43	4(250)	430	68	1849	165	0.502
46	3.33(300)	460	61	2116	156	0.516
49	3.33(300)	490	61	2401	143	0.492
52	2.22(450)	520	50	2704	142	0.545
55	"	550	50	3025	132	0.530
58	"	580	"	3364	122	0.501
61	"	610	"	2721	114	0.484
64	"	640	"	4096	106	0.460
67	"	670	"	4489	99	0.440
70	"	700	"	4900	93	0.424
73	"	730	"	5329	87	0.405
76	"	760	"	5776	82	0.388

Such a distr:bution is conditionally called theoretical. As the meshes of all cloths under examination have the squares/quadrates ($\frac{b}{h} = 1$), the coefficient of the distribution is :he function of the two determining critezia $\frac{l}{h} = \frac{l}{d_2}$ and Re. Reynold criterion was determined by the formula

$$Re = \frac{ud_2}{\nu_o} = \frac{Vd_2}{\nu_o f},$$

when $\nu_o = \frac{\eta_o}{\rho_o}$ - the coefficient of the kinematic viscosity of the air.

The research carried out showed that within the limits of the change of $\frac{l}{d_2}$ from 0.48 to 1.22 the coefficient of the distribution μ can be considered independent of $\frac{l}{d_2}$. The dependence $\mu = \mu(Re)$, based on the experimental data for all cloths that have been tested has been entered on diagram 1 in a contiruous line. On this sare graph the dependencu $\mu = \mu(Re)$ is shown by the dotted line, when

$$Re_\tau = \frac{U_\tau d_2}{\nu_o} = \frac{\sqrt{\frac{2}{\rho_o} \Delta p d_2}}{\nu_o} - \tag{6}$$

Reynold's theoretical number, calculated from the theoretical speed of flow

$$u_\tau = \frac{V_\tau}{f} = \sqrt{\frac{2}{\rho_o} \Delta p}.$$

Knowing the thickness of the threads and the density of the cloth from known formulae of textile material science[5], it is easy to determine the dimensions of the meshes $b = h = d_2$ and their area f on a single specimen. According to the formula (6) one can determine Re_τ and from the graph $\mu = \mu(Re_\tau)$ (Fig. 1) you can find the significance μ. By formula (2) can be determined the volumetrical distribution of air through the cloth. For example, for cloth No. 52 when $\Delta p = 50$ threads/square metre the experimental meaning of the volumetrical distribution of air $V_{expt.} = 3.57$ m^3/sec.

According to formula (6)

$$Re_\tau = \frac{\sqrt{\frac{2}{1.25} \cdot 50 \cdot 142 \cdot 10^{-5}}}{1.5 \cdot 10^{-5}} = 84.6$$

From the graph $\mu = \mu(Re_\tau)$ we find that $\mu = 0.75$. From the formula (2) we can determine the volume of the air:

$$V_{calc.} = 0.75 \cdot 0.545 \sqrt{\frac{2}{1.25}\, 50} \text{ m}^3/\text{sec} = 3.65 \text{ m}^3/\text{sec}.$$

The comparison of the calculated meanings of the volumetrical distribution of air with their experimental meaning (Fig. 2) shows that the deviation $V_{calc.}$ from $V_{expt.}$ lies in the limits of precision of measurement or the instrument.

CONCLUSIONS

Within the limits of change of the criterion of the geometrical similarity of the meshes of the cloths $0.48 \leq \frac{l}{d_2} \leq 1.22$ the coefficient of the distribution of air μ depends only on the number Re.

The calculation of the air-permeability of the cloth structures under examination on the dependence $\mu = \mu(Re_\tau)$ gives a good coincidence with the experiment.

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FIGURE CAPTIONS

Fig. 1: The change of the coefficient of the distribution of air μ depending on the number Re (continuous line) and the number Re_T (dotted line) when

$$0.48 \leq \frac{l}{d_2} \leq 1.22.$$

Fig. 2: The comparison of the calculated meanings of the volumetrical distribution of air with their experimental meanings for certain cloths.

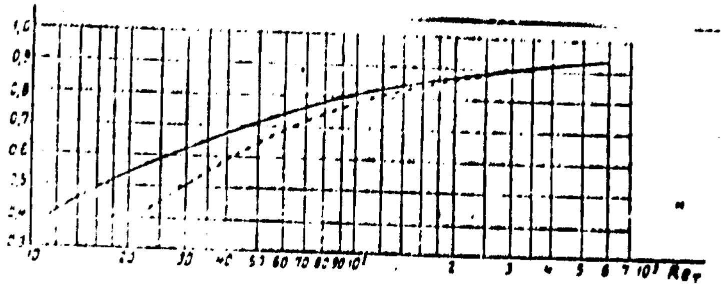

FIG 1

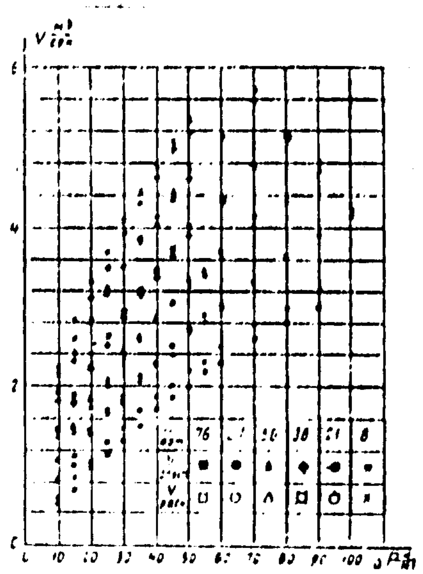

FIG 2